Computer-Aided Language Development in Nonspeaking Children

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A MAJESTIC ABSURDITY characterizes the classification system in psychiatry. Since there is such poor agreement among diagnosticians, the categories of classification are unreliable. And since there is little correlation between diagnosis, signs, and symptoms, the categories are of doubtful validity. Problems of classification are shunned by clinicians who confuse classification (forming classes in a collection of objects) with identification (identifying an object as a member of a class). Yet a more satisfactory taxonomy is crucial for clinical practice, and in particular for future research designed to yield dependable knowledge.

In the studies reported here the usual diagnostic confusions found in the classification of mental disorders among children were seen. Children from psychiatric institutions were referred for study. Each child had been previously studied at length, and their records contained the familiar terms "brain-damaged," "aphasic," "autistic," "mentally retarded," "schizophrenic." The most common terms were "schizophrenic" and "autistic," but often these seemed to stand only for "mentally disturbed." Some writers in the field equate autism with childhood schizophrenia whereas others insist these are two distinct classes of disorders.[1]

Since the field lacks agreed-upon ways for defining a diagnostic class, for identifying cases as members of that class, and for settling on a name for the class concept, the study group decided to use everyday descriptive definitions. A descriptive definition uses commonly accepted meanings of a term. Thus a "nonspeaking" child means one who does not use speech for social communication. The study group considered these children "mentally disturbed," since there was agreement at this level of description with the referring psychiatric institutions.

For the present studies referred children were accepted on the basis of a consensually observable property, namely, absent or greatly limited speech. The purpose was to try out a computer-aided method of developing language in a variety of favorable and unfavorable cases, to learn more about the advantages and limitations of the techniques involved. Thus the work consisted of empirical tests and clinical trials rather than controlled experimentation.

Language dysfunction among these disturbed children was the primary interest of the study group, and remedial efforts were in the direction of developing and augmenting language functions in nonspeaking children who had been nonparticipant in, and resistant to, social influence as affected by linguistic communication. This computer-aided method was focused directly and solely on language functions. It was not designed as a method of treatment for mental disorders. Its intent was to help nonspeaking disturbed children to acquire or augment language in the hope that they might then utilize speech in social communication. The justification for this pragmatic attempt to develop language rested on a correlation between poor treatment outcome and absence of speech in childhood mental disorders.

Two studies in the literature have indicated that poor prognosis for "autistic" children is correlated with absence of speech. Eisenberg and Kanner report a follow-up of 63 cases.[2] Of the children possessing speech after age 5, 16 of 32 patients made a fair to good adjustment. Of the 31 nonspeaking children, only one improved to a state rated as fair adjustment. However, only three of these 63 children received weekly or twice-weekly therapy, and two of those three improved. The remainder received custodial

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care characteristic of private institutions and state hospitals. Bettelheim reports on intensive psychological treatment of 40 patients, 32 improving and eight failing.[3] Of the eight failures, six were nonspeaking children, but eight of 14 nonspeaking children improved to a level of fair to good adjustment. Although it is difficult to judge whether these two studies have comparable samples of "autism" and each study suffers from sampling biases, the outcomes provide some evidence that absence of speech is correlated with poor prognosis whether the child receives treatment or not. This opinion is further corroborated by clinical impressions of experienced practitioners with whom the problem has been discussed.

There seem to be a number of different ways in which nonspeaking disturbed children can be helped to acquire speech. No one claims it is easy. Anecdotal acocunts are heard of speech development from therapists of children receiving play therapy, speech therapy, and other types of remedial efforts having no formal name. As mentioned above, Bettelheim's treatment method, which involved much more than language functions, succeeded in developing speech in eight of 14 nonspeaking children.

The recent literature contains reports involving operant conditioning methods. Using food rewards, Lovaas had some success in producing imitative speaking of single words in mute "schizophrenic" children.[4] Six children acquired a small vocabulary but did not voluntarily engage in propositional conversation.

Hewett, also using operant conditioning methods with a 4½-year-old boy, succeeded in producing a 32-word vocabulary in six months and 150 words eight months later.[5] It remained to be seen at the time of Hewett's report whether the child would use his vocabulary in linguistic communication.

Goodwin, using a "talking typewriter," has had some success in facilitating language in several disturbed children (personal communication, 1967).

Conventional psychotherapeutic and conditioning methods are slow, involve daily sessions lasting many hours, and require great human effort on the part of therapists, as well as children. A computer-aided method would be a worthwhile alternative if it could yield equal or better results in a shorter time and with less effort costs to the participants.

My group's interest in a computer-based method for developing language in nonspeaking disturbed children derived from several sources. First, we were interested in the general problem of using computers in the problems of psychiatry, as for example through computer simulation of belief systems[6] and man-machine dialogues.[7] Second, the work of Suppes[8] and Moore[9] indicates that normal children learn reading, writing, set theory, and arithmetic rapidly and enjoyably by means of computer-controlled keyboards and displays. Third, the observation of many workers regarding the great preoccupation of some disturbed children with mechanical objects which they can manipulate and control is impressive. Since language acquisition in a normal child results from interactions with people (relations which disturbed children find difficult), perhaps nonspeaking disturbed children would find a machine such as a computer-controlled keyboard and display a more acceptable source for linguistic interaction. Hence an effort was made to take advantage of a child's fascination with machines by providing him with a speaking and writing machine to play with. Instead of a person controlling a child, the child can control the machine, making it talk and display symbols at his will.

Language is often described as used for expression and as an instrument for social influence. But during normal language acquisition, it is also used by children as a toy. The method used in the present studies offered each child a means of playing with language. The hunch that children might enjoy this activity was further supported by some preliminary experience with normal children who delighted in the play and whose speech was greatly excited by it during and after the sessions. If a nonspeaking disturbed child could become interested in this sort of play and begin to enjoy developing language as play rather than work, the hope was that he would transfer his use of language from a computer context to other social contexts. If a disturbed child talks, a greater chance exists for understanding what troubles him and for helping him.

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Method

Initially the study group tried using a teletype connected to a Digital Equipment Corporation PDP-1 in the Zeus time-sharing system, at Stanford. From comparative experiences with a dozen normal children we found a Philco display to be more exciting and dramatic than a teletype. The symbols and pictures on such a display fill a screen reminiscent of a television screen. Also, the screen enables a child to point to a letter or picture, to trace symbols with his finger, and to "feel" the figures appearing before him. All this aids him in his eventual attempts to draw symbols on his own. We wanted the method to excite several sensory and motor modalities simultaneously.

The display device consists of an 8 × 10-in screen and a keyboard whose keys, when struck, produce English letters, numbers, logical and mathematical symbols, words, phrases, and pictures of objects on the screen. The display occupies about half of a 10 × 10-ft room. A speaker and two microphones, one for tape recording and monitoring the sessions and one for recording into the program, are present. Most of the time a "sitter" stays in the room with the child during his play. The sitter tries (it is hard) not to interfere or correct the child who is mainly left alone to play with the console at his own pace. Some children can be alone in the room, but others cannot be. In the early stages a sitter was present (1) to protect the equipment during aggressive outbursts, (2) to be available for any social dialogue a child attempts, (3) to repeat the sounds of letters and words made by the computer system, and (4) to excite the attention of easily distracted children who lapse into daydreaming or who, if left alone, would sit in a corner of the room. It must be emphasized that the purpose of the method was to effect an interaction, not by means of a computer alone but by a man aided by a computer. Each session lasted from 30 to 40 minutes, with frequent breaks, depending on the interest span of the child. The frequency of sessions was from one to three times a week. Since some of the children came from 150 miles away, they could be seen only once a week.

Normal children who were invited to see the system were told that it was a machine for children to play with. All of them simply started typing and immediately discovered some of the machine's interesting properties. Some disturbed children began in this way also, whereas others had to be shown how the system worked.

The program is divided into "games" of varying complexity. The sitter or the child can evoke a particular game by typing certain fixed patterns of symbols.

Game 1.—This is the simplest game, and the program for each child began with it. When a child strikes a key, its represented symbol appears on the screen and a voice from the speaker pronounces an appropriate sound. For example, if the letter A appears, the voice says "A." The symbol alternates between a large and small representation. The voice is that of an adult man or woman who speaks clearly but not professionally. At times the recordings are those of children's voices. Because of the time-sharing system, the voice response is slower than ideal for some children but others learn thereby to slow down and to listen. The taped voices can be turned off to allow the sitter to speak the symbols. The idea of this game is to acquaint the child with letters and numbers in their spoken and written forms. He learns that an action on his part produces a visible and audible response from the machine.

Game 2.—In this game only letters and numbers appear on the screen. Without the child striking a key, a letter or symbol appears on the screen and the voice pronounces it, sometimes along with hints as to where the key might be found. If the child strikes any key other than that of the letter shown, nothing happens. In 15 seconds the letter is pronounced again. Another 15 seconds passes if the child does not match the letter presented and then a new letter appears on the screen with vocal accompaniment. If the child matches the letter, it is duplicated to the right of the original, pronounced again and a new letter is presented or a picture associated with a letter appears, eg, a drawing of a bird is associated with the letter "B." The idea of this matching game is to show the child a correlation between the symbol on the screen and its representation on the keyboard.

Game 3.—When the child strikes a key a small capital letter is displayed again with the voice accompaniment, and when the next key is struck its letter appears on the screen to the right of the previous letter. The third letter appears to the right of the second, and so on, for five letters in a row. In this game a child

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can erase the entire screen by striking the tab key. A child can fill up the screen with several rows of symbols. When the space is exhausted, the top row is automatically erased, the other rows of symbols. When the space is exhausted, available for new characters. The idea of this game is to show that in written language characters are put together from left to right. Also, it offers an opportunity for the child to control symbols by making them appear and disappear.

Game 4.—When the child strikes a key, its letter is displayed with voice accompaniment; next, a blank and then a word appears with an arrow pointing to the symbol as follows:

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D    DOG
     ↑
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The voice pronounces the word or utters a phrase using the word, eg, "D like in DOG." Words and phrases which appeal to a particular child are included as well as words which appeal to children generally, eg, "ice cream." The intent is to show the child that letters make up words and that words make up phrases.

Game 5.—When a key is struck, a large symbol or letter appears on the screen without voice accompaniment. A red light on a microphone goes on and stays on for 10 seconds. During that time whatever is said into the microphone is recorded by the computer, and, when the red light goes off, what was said is immediately played back. The intention of this game is to show the child that he can speak to the machine and receive his own voice in response. If so desired, the child's voice can be permanently associated with a character so that in all the games he will hear his own voice when he strikes the key on which his voice was recorded.

Game 6.—In this game words can be constructed on the screen with an arrow pointing to any letter needing emphasis. Words up to 10 characters are permitted. The purpose here is to allow the child to practice making favorite letters or part of words which then can be saved as a permanent part of his program.

Game 7.—The sitter or child can type a word which appears on the screen without voice accompaniment. For the sitter, the purpose of the game is to test whether or not the child can read. For example, if the word "dog" is displayed and the child says "dog" or "bow-wow" or indicates in some other way he recognizes the word, he is judged able to read.

Game 8.—Without a satisfactory automatic voice-recognizing device, use was made of a person sitting in another room at a console which controls the child's screen. A letter is displayed with voice accompaniment, and, if the child responds with an utterance, the listener in the other room causes the letter to be duplicated on the child's screen. Initially any utterance is accepted by the listener. Over time the child must improve his approximation to the taped voice in order to make the second symbol appear on the screen. The intent of this game is to appeal to a child's interest in verbal magic by showing him that his speech can cause things to happen on the screen, that speech can control objects in the world.

Game 9.—A child can make pictures of animals, birds, and objects of interest appear on the screen (a) by striking certain keys, (b) by saying the word for the picture desired. The sitter points out features of the picture to the child, eg, wings on the bird, to increase the child's vocabulary. Also, sentences are associated with the pictures so that a child can imitate phrases as well as single words, eg, "birds fly," "mice eat cheese." Children who avoid the pronoun "I" can be encouraged to use it by having the sitter point to the eye of a pictured animal and pronouncing the homonym "eye."

Game 10.—A drawing of a small star appears on the screen. A child can move the drawing around by means of a light pen or by verbal command. In the latter case, a listener in the adjoining room moves the star with a light pen. Initially, simple commands are used by the sitter as illustrations—"up," "down," and "around," "dance back and forth," etc. Again the intent is to show a child that objects can be controlled by speech and to encourage verbalization, first of words and then of phrases.

Game 11.—A phrase or sentence is associated with each key. When the key is struck, the voice utters the associated phrase or sentence. Once a child has become accustomed to some of the expressions, words are omitted from them. For example, the initial expression is "We all scream for ice cream." Later the voice says "We all scream for _____" and the child is expected to fill in the missing words. Making the correct completions offers a challenge to the child.

Several additional techniques are used in this method. Mothers, foster mothers, counselors of the children, etc, are encouraged to expose them daily to TV, especially to "Captain Kangaroo" and cartoons. Television provides a rich linguistic environment correlated with visual experience. Many of the initial words used in the study program came from TV commercials and cartoons.

To facilitate transfer of learning, persons looking after the children are encouraged to point out words and letters appearing in the environment, eg, on vehicles and on signs.

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Reading a child his favorite stories is also promoted. In addition it is suggested that the children spend a few minutes each day drawing one or two letters with a felt pen on a large pad, with access to an unlimited amount of paper. Play with typewriters, tape recorders, and talking toys is also recommended. All of these ancillary techniques are intended to excite a child's interest in language as something which can be played with and controlled.

Case Descriptions

During the year 1967 my study group worked with a total of 10 children. At the time of writing this report (December 1967) we were continuing to work with some of them as well as with new cases. Each case is described briefly to indicate the sorts of events which took place. The children are identified by code initials. If a child spoke more words after involvement in the program than when he started, he was rated improved. If no increase in speech occurred, he was rated as unimproved.

CASE 1.—L. was a 7-year-old boy who between ages 3 and 4 had spoken a few brand names and had pronounced words unclearly but who later became silent. He spent hours playing with toy trains and his only spoken utterance consisted of "ch-ch," apparently referring to train sounds.

In session 1 he immediately began typing, pointing to the symbols appearing on the screen and uttering a high pitched "ee" sound. He kept a yo-yo in his left hand. After 25 minutes he made an "O" sound in imitation of the machine. His interest continued high until the session ended. (This was found to be a good prognostic sign, namely, that if a child takes to the machine promptly and has to be interrupted after 30 or 40 minutes, then his progress will be rapid.)

L. pronounced his first word "arrow" in response to the machine in session 2. In session 3 he put down his familiar left-hand object and typed with both hands. He began to practice other words silently, first making mouth movements several times and then uttering the word. He abandoned his gaze-aversion posture and looked at the sitter when pointing to a letter or saying it. His pronunciation was slurred.

By session 7 his "ee" whine disappeared and he was offering words freely. His housemother reported he called her by name for the first time. He became more assertive with other children and even aggressive, which was in marked contrast to his previous passive avoidant behavior. (This increase in aggressive behavior has been noted to occur with increase in speech acquisition in several children. See cases 3, 6, 9.)

In sessions 12-16 he showed signs of learning transfer, pointing to letters on books, posters, and signs and pronouncing them. He also began uttering imitated sentences, eg, "I like it." The driver who brought him to the laboratory reported he practiced talking a lot both on the way and on the return trip, naming objects in the countryside.

Because his pronunciation was so poor a dysarthria was initially suspected. Tests later revealed no dysarthria, and as his vocabulary increased his pronunciation improved. For session 24 his parents brought him to the laboratory. He cried, screamed, and would have nothing to do with the machine or the sitter. (This adverse effect to the presence of parents was noticed with other children.) In the next session, without his parents there, he was his jolly, laughing self.

In sessions 26-32 he began testing the limits of the sitter by playing hard to catch, ignoring the console as if he now knew what it was for. He volunteered names of objects in the room to the sitter. It was believed to be an appropriate time for teachers to take over his language development and work with him was discontinued. He had 32 sessions, about 16 hours over a period of 4 months. His linguistic development was rated as improved.

CASE 2.—N. was a 9-year-old "schizophrenic" boy who rarely had been heard to speak intelligibly. He was very frightened in the first two sessions, but by session 3 he began to play with the machine. He held his hands over his ears whenever the voice spoke. He hummed, gazed at the ceiling, and often smiled to himself.

By session 5 he began to vocalize, but no clear words appeared. He laughed a lot at the symbols on the screen. His first imitated word was "slash," in session 7. When the computer system broke down and several people were in the room he used, he refused to enter the room.

In sessions 10-15 he uttered several imitated words and pronounced many of the letters. He continued to laugh and chuckle at some secret joke. Often he attempted to disguise his pronunciation of a letter which previously he had been heard to say clearly. In session 12 he said "I don't want to," showing both his reluctance and an ability to speak sentences. The staff felt he was able to talk but was refusing to do so and was enjoying the struggle to get him to

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talk. After session 18 his visits to the laboratory were discontinued owing to an administrative decision on the part of the referring psychiatric institution.

He has 18 sessions, 9 hours over a period of 2 months. He was rated improved.

CASE 3.—B. was an 11-year-old boy who had been heard to utter 15 or 20 words during his life. His first exposure was to a teletype, which he avoided but which interested him. When introduced to the Philco display he refused to enter the room. Later in this session, however, when no one was in the room, he entered and struck a few keys. In the first sessions he glared at us angrily and replied with a scream or hand gesture when spoken to.

After four sessions in which he would not enter the room, it was decided, after consultation with his housemother, to force him in. At first he screeched loudly, pushed the keys but refused to look at the screen. For sessions 5-7 he had to be forced into the room, but from then on entered voluntarily. He screeched piercingly and did not imitate the machine's voice. From session 8 on he continued screeching but began to utter a variety of new sounds, some of which were disguises of the letters on the screen. In session 10, B. put his hand over his mouth to keep himself from talking. When he pronounced a word he looked frightened. Although he said little in the laboratory, he began to say a few words at the home in which he lived. In sessions 11-15 he struggled to hold back saying words. His housemother reported he was becoming more alert and interested in events around him.

By session 16 he showed he knew most of the letters. Each session he screeched his objection to participating in the procedure. He resisted it but was interested in it. He became more aggressive in his everyday behavior. In session 18 he said "Hi" to the sitter and replied "I know" when he was shown "2 + 2 = 4" on the screen.

In sessions 24-26 he showed slow changes. When he spoke a word or phrase, it was pronounced clearly. He was reported as speaking much more at home than at the laboratory. He seemed bored, angry, and holding out against us. His gestures became more appropriate, eg, waving bye-bye instead of using bizarre hand movements.

At the time of preparation of this report (December 1967), he had had 26 sessions, about 10 hours over 7 months. His language development was rated as improved.

CASE 4.—N. was a 12-year-old severely disturbed girl who had never been heard to utter a word except "no." She screamed often, had frequent tantrums, and feared many situations.

In the first session she screamed most of the time. Her attention to the console lasted only a few minutes, before she ran out of the room. She showed some interest in the machine and struck a few keys. From sessions 2 on she was allowed to enter and leave the room whenever she wished. She learned to strike those keys which did not produce anything on the screen. Her main activity while with the program consisted of pulling apart eucalyptus leaves and smelling them. (They have a strong, heady, camphor-like odor.) She showed no speech imitations at all and often fell to the floor kicking, screaming, and arching her back.

N.'s characteristic sound was that of heavy breathing. In session 6 these pants at times sounded like a syllable "whoosh." She spent 5 minutes in the room one time and 25 minutes the next time. In session 8 she quietly pushed the keys and watched the screen attentively. She would also look at the sitter reflectively as if about to say something, but only a scream or a "whoosh" sound would come out. If left alone, she would sit in a corner of the room sniffing leaves and ignoring the machine.

She seemed to have language comprehension, at least for simple commands. Her counselors believed her to be hopeless, both psychiatrically and linguistically.

From sessions 9-14 no change occurred. In session 15 she uttered a few syllables "chuh" and "puh." In session 17 she uttered the sound "pretz" in imitation of the machine saying "pretzel" (one of her favorite foods). In session 19 she said "tutu" (for "turtle") both in response to a picture of a turtle on the screen and when asked to say the word. She screamed less often and her huff-puff sounds became more extended into syllabic forms. Her progress was extremely slow compared with that of the other children.

In session 27 she said "tu" and "T" but looked very frightened after making these utterances. She made a "sh" sound which was interpreted to be a command to herself not to speak. At that point she was rated as unimproved after 27 sessions, about 8 or 10 hours over a period of 6 months. Work with her is continuing, in the hope some linguistic improvement will occur.

CASE 5.—S. was a 6-year-old boy whose parents were both psychotic. He made sounds and occasionally uttered words such as "dog" and "car."

He was very curious about the machine and became fascinated in the first session, making a clucking sound in response to the voice. In the second session he began imitating the "T"

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sound. At session 3 he asked a question of the sitter, "Play with this?" and pointed to the light pen. He began to point out letters on autos to other people, saying "T," "P," etc.

In session 8 he imitated the characteristic screeches and cries of two of the other children. He continued to imitate the machine and enjoyed the play greatly. By session 13 he knew all the letters and could play Game 2, the matching game, easily. He learned to read and type words and began to draw letters and words on a pad. In session 16 he brought a toy train. Since he was interested in trains and cars the words in his program referred to the parts and functions of these machines. He became much happier, smiled a lot, and greeted people. He decorated his room with drawings of trains, cars, words, and letters.

After session 20 his first propositional speech began. He addressed sentences to his counselors, some imitating the machine and some self-constructed. Some of his pronunciations were unclear, eg, "pish" for "fish."

He has had 28 sessions, about 14 hours over 6 months. He was rated as improved. He will continue in the program a while longer, although he is close to the point where others can take over his language development.

CASE 6.—M. was a 12-year-old boy who had no speech but could understand language. He made many peculiar hand and head motions. He continuously jiggled a small object in one hand.

In session 1 he said nothing. In session 2 he made a "Go" sound in imitation of the machine. In session 3 he repeated a few of the letters in disguised form. To prevent himself from speaking he would curl his tongue around in the bottom of his mouth. He made his first verbal social communication to his counselor, saying "Ga." At the machine his attention would drift off with an increased rate of jiggling until the sitter brought him back to the screen by tapping it and repeating the voice sounds. Although he had previously been a very isolated child, his social communication by sounds became more frequent. He learned to swim, an activity he had refused to participate in previously.

In session 6 he tried multisyllable sounds "Ga-ga-ga-ga" in response to the machines "twinkle, twinkle little star." His first recognized word was "cookie" in session 9. He became much more aggressive and assertive with both adults and children. In session 10 he was very upset for unknown reasons, crying and refusing to play with the console. In the next session he was happy again. He enjoyed physical play with the sitter, slapping and poking him tentatively. At this point his language behavior did not progress much but his general behavior in the sessions changed greatly. The school teacher who worked with him reported that of all the children M. had changed the most dramatically in his everyday behavior.

By session 15 he still spent much of his time laughing and playing with the sitter, testing his limits to see how much of not playing with the machine he could get away with. He correctly imitated the syllables in "kangaroo." He laughed at some of the absurdities included in his program, eg, when he struck the call key, the machine replied, "hello, M_____." In session 17 he said "O," "9," and "E" repeatedly. He curled his tongue whenever he wanted to stop. In session 18 he began to pay close attention to what happened on the screen.

He had 18 sessions, 7 or 8 hours over 5 months. He was rated as improved and work with him is continuing.

CASE 7.—P. was a 12-year-old very docile, sloth-like nonspeaking boy. He understood language and at times volunteered a mispronounced word.

In session 1 he slowly and methodically tried each key on the keyboard, making a verbal response to a few of them. To command the star in session 2 he said "Go light" instead of "Go right." He enjoyed the play and smiled a bit at some of the machine's absurd responses.

In session 3 he was less zombie-like. He imitated some of the letters, even saying them before the voice accompaniment of the machine. In session 6 he began to imitate sentences. He laughed freely, spoke the sitter's name and showed he knew all the letters.

In session 7 he was much more alive. He concentrated on the games. He mentioned the sitter's name frequently when away from the laboratory.

At this point his parents decided to withdraw him from the institution in which he was living and to keep him at home. His parents were informed of his participation in the program and of the staff's interest in helping him with his language problems. The parents did not reply.

He had seven sessions, about 3 hours over 2 months. He was rated as improved.

CASE 8.—C. was a 9-year-old boy who made unintelligible sounds. He was wild, impulsive, impatient, and short-tempered.

In the first session he took to the machine immediately. He laughed but did not speak. In session 2 he particularly enjoyed Game 3, in which he could erase-out symbols. He said something close to "era-out" in imitation of the sitter. He was easily frustrated. It was hard for

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him to slow down his striking of the keys in order to hear the machine's voice. He had violent tantrums when one of the other children teased him.

In session 4 he was extremely upset by his mother's presence in the laboratory. Any prohibition threw him into a tantrum of screaming.

In session 5 he was calmer and only pouted when the machine would not do his bidding. When shown the star he sang the first few bars of "Silent Night." He showed he already knew many of the letters and words. His house mother reported that he spoke in repeated stereotyped sounds.

In session 6-9 he began to speak words with a highly garbled pronunciation. He became interested in drawing letters and would print a word if the sitter told him each letter. In session 10 he spoke many words and sentences, both imitating the machine and volunteering. His house mother reported he had "come alive" in those two months. In session 13 he learned to type and speak the numbers above 9. His pronunciation began to clear and others began to understand what he was asking for when he made a request. Being able now to communicate his wishes, which others could do something about, he found himself frustrated less often and thus less given to tantrums. This change in his impatient short-temperedness was striking to all who knew him.

By session 14 he was talking freely and volunteering sentences to a number of persons. He conversed with the machine as if it could understand him. His house mother reported he surprised her with new sentences every day.

He had 17 sessions, 8 hours over 4 months. He was rated as improved and work with him is continuing.

CASE 9.—E. was a 6-year-old boy who had a vocabulary of many words but who did not use them appropriately. He did not imitate or volunteer sentences.

Although he enjoyed the machine in the first session, he lost interest after 15 minutes. In session 2 he repeated several letters after the voice, with correct pronunciation. He approached various people saying "bulb, bulb," apparently meaning he wanted a light bulb (a toy his mother forbade him) to play with. His speech was very robot-like, without inflection.

In sessions 3-4 he began to resist playing with the machine, preferring to show interest in other objects in the booth. It was believed he knew what the staff's purposes were regarding his speech and he busied himself in thwarting them. He exclaimed "Daddy!" in response to a picture of a large upright duck.

But in session 6, although he still had short attention, he began to try crude sentences in imitation of the machine. One problem was in getting his mother to let him watch television. E. was in a power struggle with his mother, the withholding of feces being his major weapon.

In session 7 he imitated both machine and sitter well. If asked a letter he did not know, he would reel off a list of words he did know, "Mommy, Doctor, purple grape, bulb." He recognized and spoke the letter "A" before the machine's voice pronounced it.

His mother reported his vocabulary was expanding rapidly. He watched "Captain Kangaroo" daily on television, laughing, humming, and talking in response to it. In session 10 he attempted an approximation of the six-word sentence "The cow jumped over the moon." This was in contrast to his offering only one word at a time at home.

After session 10 his mother reported he was trying two- or three-word sentences at home. In sessions 11-14 he continued to try longer sentences, having many pronunciation problems and dropping some of the words. In session 15 the sitter easily taught him to sing the first line of "Jingle Bells." After session 16 he said to his father at home "You know the cow jumped over the moon."

In session 18 he showed a confusion understandable in this context, ie, he would repeat a question rather than answer it. Whether he actually had a poor memory or whether he was electively disguising his memory abilities could not be determined.

He became more aggressive with adults and children. His mother reported he volunteered multiword sentences. In session 21 he uttered a few sentences to the sitter.

At that point his mother enrolled him in a school for the educationally handicapped. It was too difficult to schedule him both for school and for our laboratory so his participation in the program was discontinued. He was rated as improved.

CASE 10.—D. was a 3-year-old boy who had never uttered a word. He made humming sounds and comfort-discomfort cries. He never babbled as a baby and did not appear to have any language comprehension. He was considered to be aphasic and/or autistic.

In session 1 he played with the keys but did not look at the screen and made no sounds. In the second session he became interested in the screen and traced letters with his finger. In session 4 he said "nine" twice in imitation of the machine. But from session 5 through session 21 he uttered no further words. He cried a great deal in objection to being forced to stay in the room and play with the machine. At

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home he learned to respond to the word "kiss" but showed no other indication of understanding the simplest commands or references.

D. was an extremely hyperactive and negativisitic child. He had to be watched every minute or he would run away. His mother reported he seemed eager to come to the sessions but once there he became very resistant to influence. His sessions were increased in frequency to three times a week, with little effect. At times he did seem to understand words but to simply shut them out. Apart from his crying in protest, his only sounds were a rare "mm-m." He refused to put anything in his mouth. His mother reported he would neither blow nor suck. At home he began to make a greater variety of sounds but none was used for communication. Slowly he began to show signs of some language comprehension, fetching objects on command and responding to "Where's Daddy?" by running to the window to see his homecoming father. In the sessions he made sotto voce sounds to himself. At times he would listen to the machine voice and watch the screen. In session 34 he enjoyed playing with the red-light microphone but said nothing. He was the slowest to respond of all the children in this group.

In the sessions he would wave bye-bye when the voice said "bye-bye." He also learned to clap hands when the voice said "H is for clap hands." At home he was very difficult to manage and began to wear his parents down. His father suffered a coronary attack and his mother began seeing a psychiatrist, who put D. on a tranquilizer to control his hyperactivity. By session 44 his mother reported his comprehension vocabulary was increasing slowly, as he responded appropriately to "coat," "shoe," etc.

At the time of writing this report D. had 44 sessions, about 20 hours over a period of 6 months. He was rated as unimproved. Work with him is continuing in twice-a-week sessions.

Results

With this sort of heterogeneous sample it is unjustified to construct an ordinal or even partially ordered measurement scale along which the children can be compared reliably with one another. Each child was rated as improved or unimproved relative to his own starting point. As mentioned, if the number or appropriate use of words in a child's speech increased he was rated improved. If no such increase was noted, he was rated unimproved.

In a group of ten nonspeaking disturbed children, eight improved in their language development and two did not. Three reached the level of propositional speech. This improvement rate of 80% is encouraging, particularly as it was achieved in such a short time and with such little effort compared with that of other methods for developing language.

Comment

Language acquisition in normal children is believed to occur as species-specific behavior in humans according to a rough maturational and developmental timetable.[10] If a child does not develop speech by the age of 36 months, the disorder is serious and a search for his trouble should begin.

Deafness, organic brain disease, and mental retardation are the conditions to be considered first. Developmental aphasia or apraxia and a mental disorder, either singularly or in combination with the above conditions, are further possibilities. Although the neurophysiological mechanisms for speech are unknown, aphasias and apraxias are considered to represent physical inabilities. Absent or limited speech on the basis of a mental disorder is currently considered to be voluntary and elective. It is often difficult to determine whether a given child has the physical ability to speak when no one has ever heard him speak. One aid in making this determination is a voice-activated tape recorder, which can be used to record any sleep-speech of the child.

Some of the nonspeaking children in the program were able to comprehend language and to speak a few words intelligibly. But, for reasons which are not well understood by anyone, they did not speak at all or offered idiosyncratic expressions in particular contexts. All the children with whom work was done showed periods of great resistance and negativism toward the efforts of the staff. At one time the children would be greatly interested in the games and at another time they would balk at all attempts to get them to play with the machine.

Normal children do not have to be taught to speak by any special methods. They build up language functions through an ability to combine linguistic data provided by the en-

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vironment with cognitive-affective capacities. All but one of the children under study seemed to possess this ability but resisted using it. Why they chose to be silent remained a mystery. It was assumed that each child had some purpose for his silence. The task was to try to help the child to speak without knowing specifically what his concepts and beliefs were about nonspeaking. Nor was it known explicitly why he would so strongly resist efforts to budge his position. It was assumed he felt threatened in some way and that he was obeying a self-generated, and perhaps linguistically formulated, imperative not to speak. Lacking further information, the study group could not infer much beyond these rough assumptions.

Often it was found difficult to estimate how much language comprehension and speaking ability a given child had. A variety of observers would offer information about words or sentences they had heard from the child and recall instances of comprehension. All the children made sounds. Some children would imitate single words or phrases and some would at times volunteer an unintelligible utterance. When a child volunteers a single word, the proposition involved can be obscure to an observer. For example, when looking at the rain, a child may say "wet." What proposition does he have in mind—"the rain is wet," "I like it wet," "water is wet"? As with a normal child, someone who knows the nonspeaking child well can often guess the proposition being referred to by a single word. The goal of my study group was to move from sounds to words to sentences, at first imitated and then volunteered. It is when a child voluntarily participates in propositional speech, sharing his ideas with others, that linguistic communication can be considered to be within the normal limits.

Some of the studied children achieved the goal of volunteered propositional speech. Others improved from single-word utterances to sentences. Some of the children changed their personal-social as well as linguistic behavior during the period of treatment. Can these effects be attributed to the application of the method used? It would seem a reasonable hypothesis to believe so, but the data from this sample cannot exclude plausible alternative hypotheses. All of the children were receiving concomitantly a variety of treatments. How should the credit be distributed? To answer questions on the effectiveness of this computer-based method one would need a controlled experimental design with comparable homogeneous samples of children. The purpose in reporting this work is simply to describe what was done and what resulted. The results thus far are sufficiently promising to justify further studies.

Using uncontrolled data from a heterogeneous sample it is futile to attempt to develop a reliable explanatory theory. It is a fact of empirical observation that there is something about the experience of playing with this computer-controlled systems which excites and interests both normal and disturbed children. If there exist some built-in mechanisms which resonate to linguistic output, then this method might be assumed to excite them. Although speculation was made about essential variables, no attempt was made by the study group to set the principles of anything which might be called theory. And from a practical viewpoint, the group recognized that the most powerful methods for applying this technique are yet to be determined. Further intuitive inventiveness is required.

Nonspeaking disturbed children reject the use of linguistic communication. Attempts by others to change this rejection might be perceived by the children as threatening. Hence the question of regressive effects must be considered. Faced with the loss of a cherished coping mechanism (if that be the case), a child might regress further and attempt some other means of withdrawing. Although the staff was alert to the possibility of some children becoming more disturbed, no such result was observed.

Finally, the question of using computers for the improvement of linguistic communication should be reviewed briefly. Many of the techniques in the method described above could be carried out without a computer. A number of workers in the field who do not have access to a computer have been encouraged to try these techniques by using typewriters, slide projectors, language toys, and other devices which are simple and inexpensive to buy or construct. The main advantage of a computer-controlled system is its

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great consistency and imperturbability. It can be viewed as a catalytic agent which enters into an interaction and accelerates a process without being changed itself. Disturbed children do not resist learning: they resist being taught by people. One trouble with therapists and teachers is that, being human, they tend to become tired, bored, angry, and inconsistent in their approach. They vary in their interactions with children and become thereby changed themselves, often with negative effects. Disturbed nonspeaking children need a stable, consistent, patient, and tireless agent for language development. For this a computer is ideal.

Future Prospects

There are a number of ways in which this computer-aided method could be improved. It is hoped that our results will encourage other workers to do so.

Regarding computer hardware, there is no need to use a large time-shared machine. In fact a time-shared situation, with a large number of users, tends to slow down the response time. A better system would involve a small computer with a few terminals which are devoted entirely to language development problems. Psychiatric centers and speech pathology institutes should have their own special-purpose computer hardware. Programs for dozens of children could be run each day on such a system. The system could be used not only for language problems in children but also for adults with aphasias.

A great variety of programs could be written for a flexible special-purpose system. For example, the symbols and drawings appearing on the screen can be animated. Motion is an important part of concept development for many verbs. Computer-controlled toys are possible in which the toys' behavior can be controlled by typed or spoken commands.

Finally, little experimental work has been done in investigating childhood mental disorders from an information-processing standpoint. Many researchers believe that "autistic" children suffer from some specific cognitive or affective deficiencies. However, these ideas have not been explored sufficiently. A variety of tests and experiments could be introduced while a child is playing with a computer-based system able to control symbols and objects. Cognitive and affective processes of children who reject being tested by people but accept a computer-based situation would be accessible for systematic study.

Summary

Results of implementing a computer-based method for aiding language development in nonspeaking mentally disturbed children showed that, of ten children treated, eight improved linguistically and two were unimproved. Problems with the method include theoretical development and the need for technical improvement and research.

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